TCM Update

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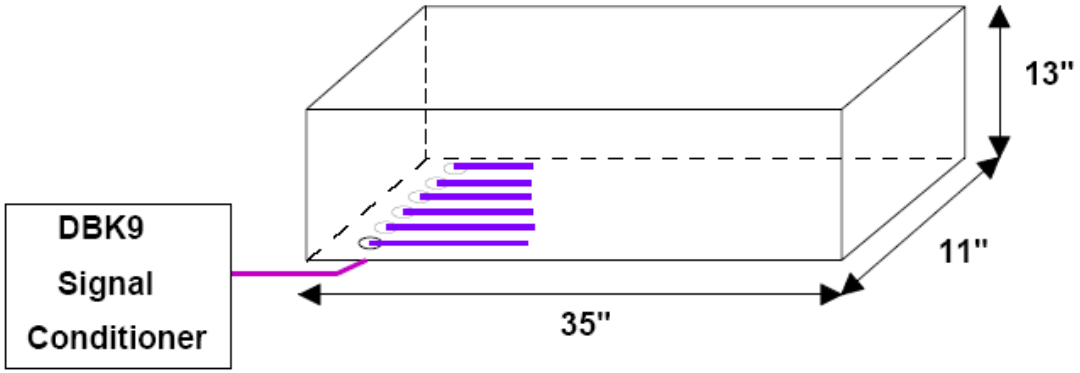
9.9.10

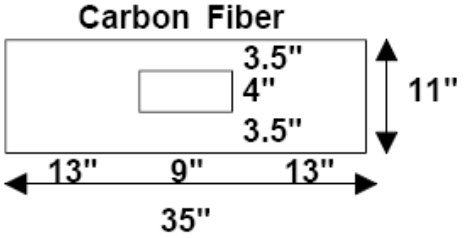
TCM Webpage

http://www-ppd.fnal.gov/EEDOffice-w/Projects/CMS/Silicon_Tracker/

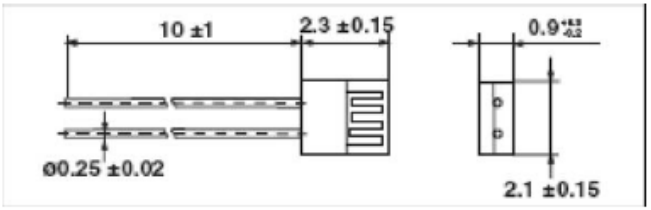
- Silicon Track Trigger Upgrade Carbon Fiber Thermal Conductivity Measurement
  - Graphics
    - Al 6061 T651 bar/RTD graphic
    - Vacuum Chamber graphic
    - RTD Cable Bundle graphic
  - Documents
    - Cable list
  - Engineering Calculations
    - Temperature Gradient
    - Losses
    - Spreadsheets

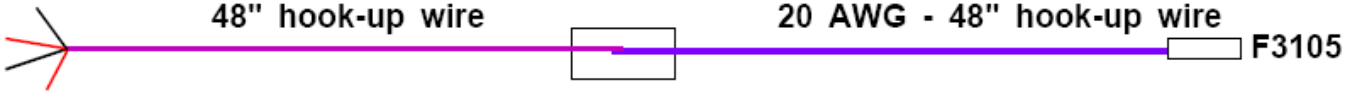
TCM Vacuum Chamber





F3105 RTD Dimensions

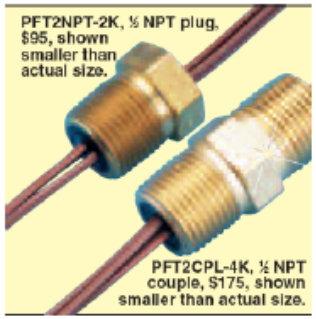




PFT2NPT-4CU

4prs = 8/4=2 RTDs

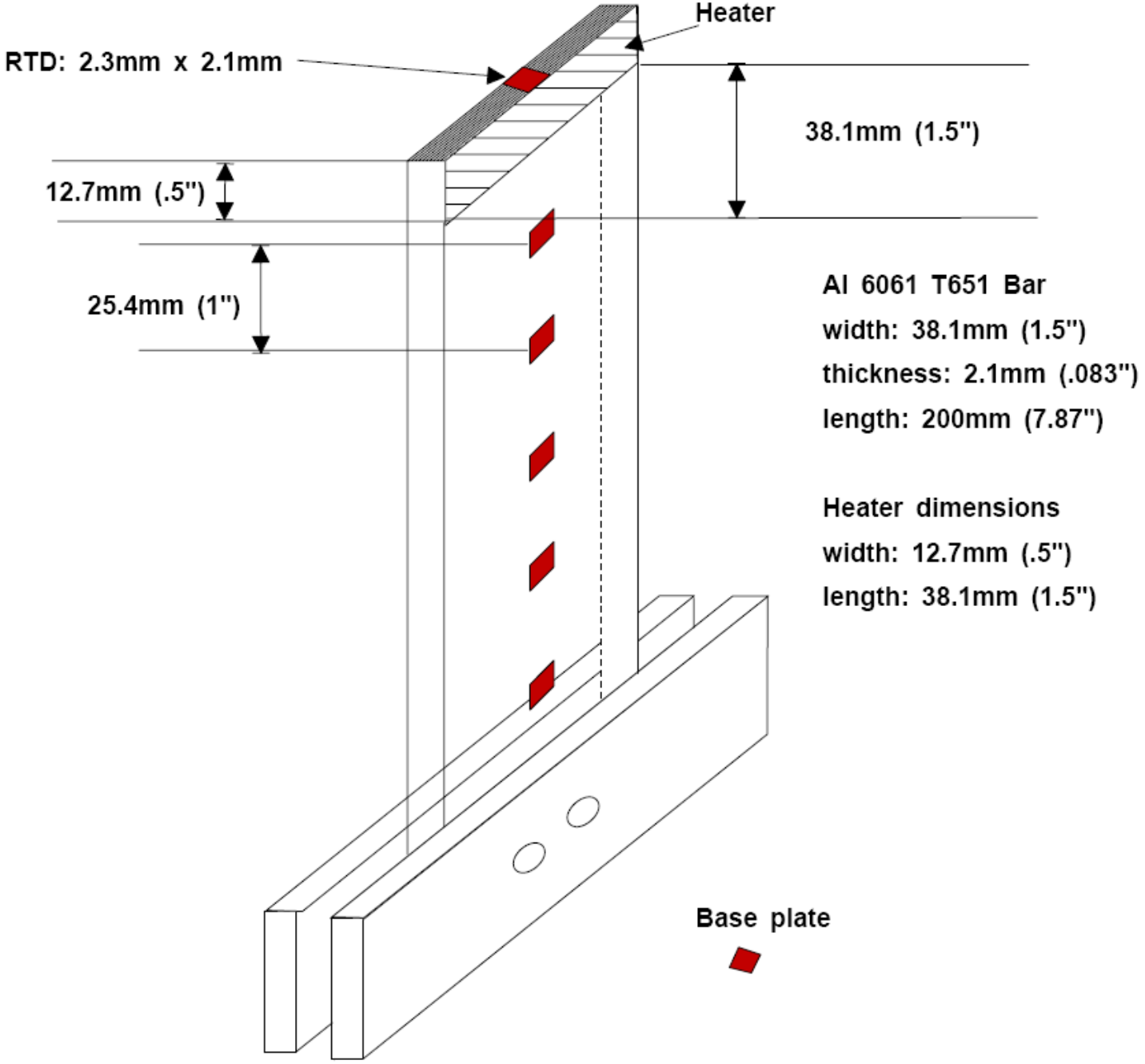
for 12 RTDs 6@$120=$720



F3105 - Class A

100 Ohm ~2mm x 2mm

$19 * 12 = $228

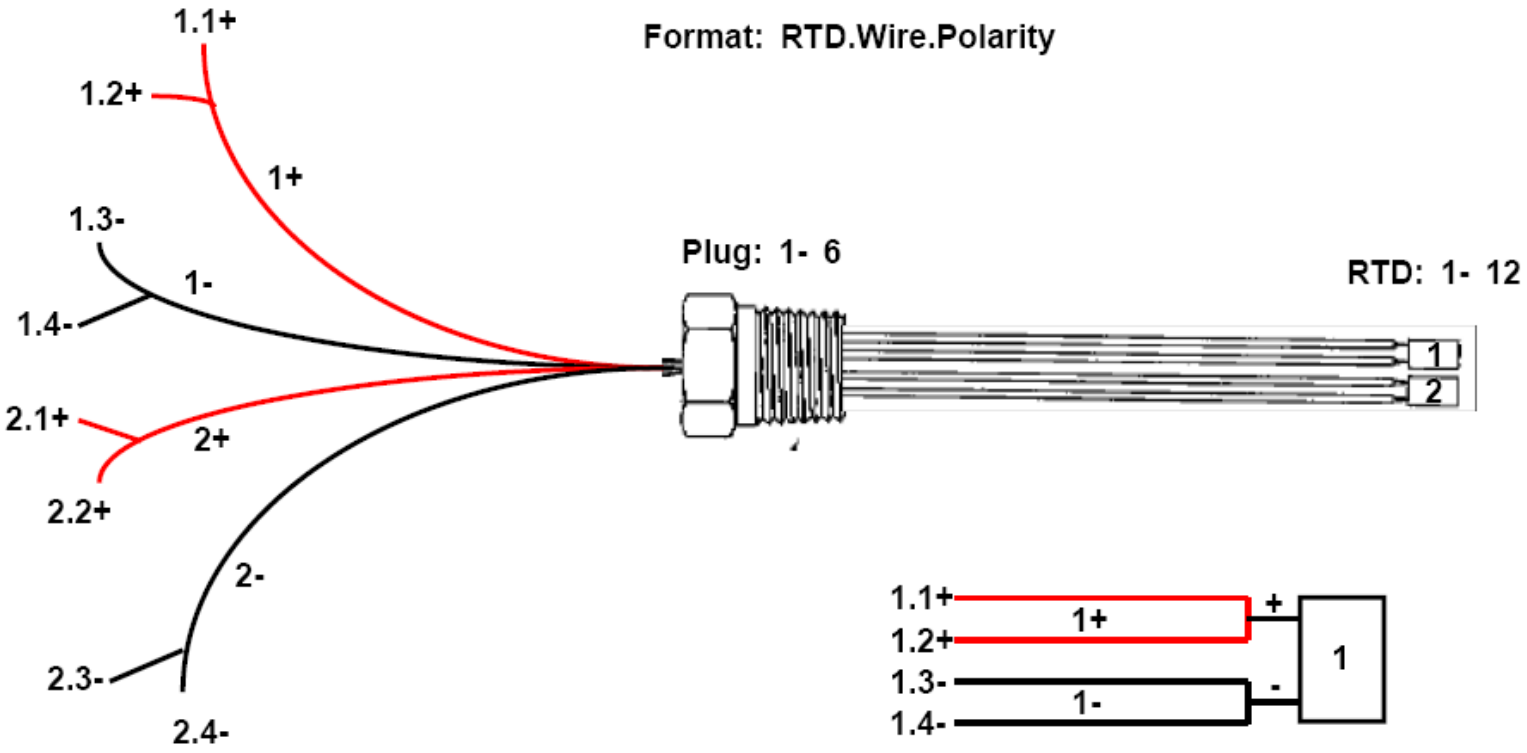

Heater
RTD: 2.3mm x 2.1mm
38.1mm (1.5")
12.7mm (.5")
25.4mm (1")
Al 6061 T651 Bar
width: 38.1mm (1.5")
thickness: 2.1mm (.083")
length: 200mm (7.87")
Heater dimensions
width: 12.7mm (.5")
length: 38.1mm (1.5")
Base plate

Plugs numbered 1-6.

RTDs numbered 1-12.

Wires numbered 1-4 for each RTD.

Format: RTD.Wire.Polarity



Fermilab-Linda Bagby

P/N OSK2K2595/PFT2NPT-4CU

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Temperature Gradient

Q (W)	k (W/mC)	A (m^2)
1	167	8.00E-05

74.85 C/m

dT/dL = q/kA

Face area

		L (m)	C
dT/dL=	74.8502994	0.2	14.97

dT between each RTD is 1.9 C

RTDs ~1" apart

dT between top of bar and first RTD ~1.7C

Area = (38.1mm)*(2.1mm)

Assuming 1W input

dT	L(m)	dT@RTD
34.970	0.0000	
33.308	0.0222	1.662
31.407	0.0476	1.901
29.506	0.0730	1.901
27.605	0.0984	1.901
25.704	0.1238	1.901
23.802	0.1492	1.901
21.901	0.1746	1.901
20.000	0.2000	1.901

length (m)	dT from source	34.97	dT @ RTD
0.0222	1.66167	33.30833	1.66167
0.0476	3.56286	31.40714	1.90119
0.073	5.46405	29.50595	1.90119
0.0984	7.36524	27.60476	1.90119
0.1238	9.26643	25.70357	1.90119
0.1492	11.16762	23.80238	1.90119
0.1746	13.06881	21.90119	1.90119
0.2	14.97	20	1.90119

The face area is calculated using the dimensions of the Al bar.
Width: 38.1mm
Thickness: 2.1mm

Summary--
The temp grad along a 200mm long bar is ~15 C. If each RTD is spaced 25.44mm apart, there is ~2 degree temp difference.

Radiated and Conductive Losses

Radiated Power loss of Al face			P=eσA (T^4-Tc^4)	2.59E-03 **2.6 mW**
e (emissivity)		0.35	1.59E-12	
σ (Stefan-Boltzmann)		5.67E-08		
A (face)	(38.1 x 2.1)	8.00E-05		
T (35-20)	(308^4-293^4)	1.63E+09	1629127695	

Total Al surface area loss		Area	P
Front/Back	38.1 x 200	1.52E-02	4.93E-01
sides	2.1 x 200	8.40E-04	2.72E-02
top/bot	38.1 x 2.1	1.60E-04	5.17E-03
Sum		1.62E-02	**5.25E-01**

Conductive loss in 4 20AWG area				
k	4.01E+02		P=kA(dt)/L	0.002553
A= (PI r^2)	5.18E-07		dT = 15C	**2.5mW**
L	1.22		each RTD (*4)	1.02E-02
dT in C	15			**10mW**

10mW for each RTD, worse case

Radiated Power Loss	5.25E-01	**525 mW**
Conductive wire loss (ea RTD)	1.02E-02	**10 mW**
surface loss	**52.50%**	
wire loss	**1.02%**	

Dan's Bar		top/bot	.5 x .25	1.61E-04	
e (emissivity)	0.35	sides	.25 x 7.874	2.54E-03	
σ (Stefan-Boltzmann)	5.67E-08	front/back	.5 x 7.874	5.08E-03	
		Total Area		7.78E-03	2.14E-01
T (32-18)	1.38E+09			**21.40%**	**214 mW**

AL 6061 T651 Bar
12.7 mm wide
6.35 mm thick
167 W/m-K

sensor	T_0	T_1	T_2	T_3	T_4	T_5	T_6
position[m]	base plt.	0	0.05	0.1	0.15	0.2	on ht.sink

Date	Time	Voltage	Current	q_in [W]	T_0	T_1	T_2	T_3	T_4	T_5	T_6	
26-Oct	849	19.54	0.056	1.094	17.995	31.576	28.405	25.282	21.953	18.790	18.293	
notes:				0.885								q=VI-eσA(T^4-Tcold^4)
vacuum = 6e-5 Torr				0.209	expected dT/dL		T1-T2/dL	T2-T3/dL	T3-T4/dL	T4-T5/dL	T1-T5/dL	A=7.78 x 10^-3 m^2
No superinsulation.					81.2 K/m		63.4	62.5	66.6	63.3	63.9	K/m
32-gage, 4-wire on strain gage heater							78%	77%	82%	78%	79%	
Thermal grease between sample, sink, and base					65.7		96.48%	95.01%	101.28%	96.23%	97.25%	expected=q/face A

Radiated power loss

Date	Time	Voltage	Current	q_in [W]	T_0	T_1	T_2	T_3	T_4	T_5	T_6	
26-Oct	1700	19.54	0.056	1.094	21.320	35.052	31.875	28.539	25.155	21.962	21.477	
notes:				0.873								
vac=1.2e-4				0.221	expected dT/dL		T1-T2/dL	T2-T3/dL	T3-T4/dL	T4-T5/dL	T1-T5/dL	
No superinsulation. Thermally anchor thermistor					81.2 K/m		63.5	66.7	67.7	63.9	65.5	K/m
leads to bar. 32-gage, 4-wire on strain gage heater							78%	82%	83%	79%	81%	
Thermal grease between sample, sink, and base					64.8		98.01%	102.91%	104.39%	98.50%	100.95%	

Date	Time	Voltage	Current	q_in [W]	T_0	T_1	T_2	T_3	T_4	T_5	T_6	
29-Oct	826	19.54	0.0561	1.096	22.181	36.057	32.899	29.567	26.194	23.003	22.501	
notes:				0.873								
vac=5e-5				0.223	expected dT/dL		T1-T2/dL	T2-T3/dL	T3-T4/dL	T4-T5/dL	T1-T5/dL	
No superinsulation. Thermally anchor thermistor					81.4 K/m		63.2	66.6	67.5	63.8	65.3	K/m
leads to bar. 32-gage, 4-wire on strain gage heater							78%	82%	83%	78%	80%	
Thermal grease between sample, sink, and base					64.9		97.39%	102.75%	104.02%	98.41%	100.64%	

Date	Time	Voltage	Current	q_in [W]	T_0	T_1	T_2	T_3	T_4	T_5	T_6	
29-Oct	1230	19.55	0.056	1.095	23.416	34.34	31.593	28.942	26.439	24.200	23.852	
notes:				0.922								
NO vacuum				0.173	expected dT/dL		T1-T2/dL	T2-T3/dL	T3-T4/dL	T4-T5/dL	T1-T5/dL	
Using superinsulation. Thermally anchor thermistro					81.3 K/m		54.9	53.0	50.1	44.8	50.7	K/m
leads to bar. 32-gage, 4-wire on strain gage heater							68%	65%	62%	55%	62%	
Thermal grease between sample, sink, and base					68.5		80.23%	77.43%	73.10%	65.39%	74.04%	